



*Photo by John Durand*

# American River Salmon

## Educator Activity Guide



*Bobbie Winn*

Bobbie Winn  
Project Coordinator





# Table of Contents

## Introduction

Introduction and Acknowledgements	4
-----------------------------------	---

## Overview

What Are Salmon?	5
Salmon Life Cycle	7
Watersheds: The Link to the Ocean	10
Cultural Perspectives and Human Impact	12
Salmonids at the Hatchery	15

## Unit 1: FISH PHYSIOLOGY

Fishy Facts	16
<i>Fishy Facts Review</i>	17
<i>Fishy Facts Revealed</i>	19
<i>Fish Adapted to Life in the Water</i>	20
Fishy Facts for Early Childhood Education	21
<i>Fish Puzzle!</i>	22
Fashion a Fish	23
<i>Fish Adaptations</i>	25
Light Vision	28
Variations on a Theme	31
<i>Salmon &amp; Steelhead Fact Sheet</i>	34
<i>Salmon &amp; Steelhead Venn Diagram</i>	35
<i>Salmon &amp; Steelhead Game</i>	36
Finger Fish: Five Kinds of Salmon	37
<i>Color the Fish!</i>	38

## Unit 2: LIFE CYCLE

<i>Salmon and Steelhead Life Cycle</i>	40
The Salmon Story	41
The Great Anadromous Fish Game	43

<i>The Great Anadromous Fish Game</i>	45
---------------------------------------	----

<i>Game Rules</i>	48
-------------------	----

Hooks and Ladders	55
-------------------	----

Early Childhood Education Hooks and Ladders	60
---	----

Homing Instincts	63
------------------	----

<i>California Waterways</i>	66
-----------------------------	----

## Unit 3: WATERSHEDS AND AQUATIC ECOSYSTEMS

Watershed Model	67
<i>Watershed in Your Hands</i>	71
Home Wet Home	72
<i>Teacher Reference</i>	74
<i>Home Wet Home Facts</i>	75
<i>Riffles and Pools Worksheet</i>	76
<i>The River from Above</i>	78
Erosion: Water + Soil=Impact	79
<i>Erosion Observation Chart</i>	82
Stream Planning	83
<i>Water We Going to Do?</i>	85
Aquatic Ecosystems 2-5	86
<i>Master Script</i>	88
Aquatic Connections 3-8	94
<i>Aquatic Connections Worksheet</i>	98
<i>Aquatic Food Web</i>	99

## Unit 4: STEWARDSHIP

Designing Hatcheries with Genes in Mind	100
<i>Designing Hatcheries</i>	103
<i>Hatchery Operation Problems</i>	104
<i>Hatchery Cards</i>	105

# Introduction

The theme of the American River Salmon Festival is; “Celebrate the Importance and Conservation of Chinook Salmon.” The Festival Schools Day committee is responsible for providing educators with professional development opportunities and educational materials for classroom use. Until 2003, educators attending the American River Salmon Festival Teacher Workshop were provided a copy of *Some Things Fishy, A Teacher’s Guide for the Feather River Fish Hatchery*, developed by California Department of Water Resources for the Feather River Hatchery program. It was the goal of the Schools Day Committee to produce materials specific to the salmon of the American River watershed. Materials distributed for grades K-8 focus on increasing the student understanding of salmon ecology and resource conservation. In 2003, a special Sports Fish Restoration Grant provided the funding to accomplish this goal.

This guide provides background materials specific to the American River watershed. The activity guide targets grades Kindergarten through 8th grade, is correlated to the California Educational Content Standards, and contains assessment tools. The guide was developed using materials and adaptations from a variety of sources, each source is noted at the conclusion of the activity. Activities are arranged in units and are placed in order of complexity. Each activity provides the educator with background information and requires minimal preparation. There is an assessment with each activity as well as an overall assessment at the end of the guide. Refer to the

## Acknowledgements

This activity guide is the product of the American River Salmon Festival Schools Day Committee which represents a partnership of agencies with an educational commitment. Members include:

John Durand, Galt Joint Union School District  
Beth Etgen, Effie Yeaw Nature Center  
Meg Grow, CA Department of Fish and Game  
Sylvia Gude, Volunteer (Department of Fish and Game – retired)  
Lesa Johnston, CA Department of Fish and Game  
Ken McCulloch, City of Sacramento Parks and Recreation  
Viola Taylor, U.S. Fish and Wildlife Service  
Bobbie Winn, CA Department of Fish and Game

Many THANKS to the educators who piloted these activities and provided assessment and comments.

Linda Desai, Eugenia Kawashima, Megan Lipman, Shulah O’Hara,  
Aaron Pollock, Shalonn Snider, Teri Thomas and Joanne York

Also, THANKS to these member of the Department of Fish and Game staff:

David Moore, Rick Parmer and Robin Wade for review and comments,  
Alisha Jurick, who’s technical skills that made this guide a reality, and  
Jillian Hart for proof-reading and editing.

# What Are Salmon?



***Salmon are fish.*** What is a fish, exactly?

Fish are aquatic animals adapted to life in fresh or salt water. Fish come in many sizes, shapes, and colors. There are tiny fish, giant fish, flat fish, skinny fish, flying fish, electric fish, and fish that live in schools. Although there are about as many kinds (species) of fish as mammals, birds, reptiles and amphibians put together, the habitat and behavior of fish make them difficult for people to observe in nature.

Because of the variety of conditions within each habitat, many different fish can live together and flourish. Fish can be found wherever there is water, such as salt water (like the ocean), freshwater (like lakes, ponds, streams, and rivers), and places where salt and fresh water meet (these are called estuaries).

Fish are cold-blooded vertebrates with gills, fins, and a body that is usually covered with scales. Fish breathe oxygen with gills, which are covered by *opercula* (gill covers). Fish can sense their environment in a variety of ways. Along what is called the lateral line, fish have sensors that detect motion, vibration, and sound. Salmon also have an excellent sense of smell. If you look at a salmon, you won't see an obvious nose. Instead, look for two comma-shaped holes on either side of its head below the eyes. Water flows in one hole, over the olfactory receptors that absorb molecules from water, and out the other. These receptors convey information to the fish about its environment. Consequently, salmon can detect minute amounts of dissolved substances.

## ***The Salmonoids***

Scientists classify all plants and animals into identification groups. The many varieties of salmon and trout are in a group known as *salmonoids*. The American River Watershed is home to Chinook salmon and steelhead trout.

Salmonids date back to the Miocene geologic era, and evolved in the cold, oxygen-rich waters of the northern hemisphere. Their unique migratory behavior is believed to have originated over 10,000 years ago as a result of the advancement and receding of the continental ice sheets. About this time period the Pacific salmon became separated from the parent salmon stocks in the Atlantic, and as the great glaciers of the Ice Age melted, safe places for spawning and rearing were revealed.

Most fish live in either salt water or freshwater. But, some fish are diadromous (dye-AD-ruh-mus), which means they can live in fresh and salt water at different times in their lives. Diadromous fish are divided into the following two groups:

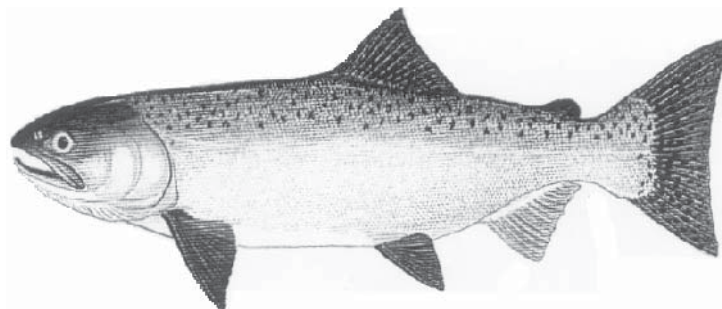
- 1) Anadromous (ah-NAD-ruh-mus) fish begin their lives in freshwater, move to salt water to feed, and return to fresh water to spawn.
- 2) Catadromous (ca-TAD-ruh-mus) fish are born in salt water, move to freshwater to feed, and return to salt water to spawn (lay their eggs).

Salmon and their relatives, steelhead, are anadromous fish. They begin their lives as eggs in cold mountain streams, grow to adults in the Pacific Ocean, and return to their natal streams to spawn.

It seems difficult to understand how a way of life involving dangerous journeys and high risks could be beneficial. However, consider where salmon live. On a yearly basis, the Pacific Northwest endures floods, landslides, droughts, and fires. Periodically, catastrophic events occur such as volcanic eruptions or ocean disruptions such as El Niño. Salmon, as a species, survive these upheavals because of their adaptability and strength, and because they have a large population divided into hundreds of small populations throughout their range.

Picture the many populations of salmon as a tree. That's how the National Research Council illustrates the salmon population in the book, *Upstream: Salmon and Society in the Pacific Northwest*. The trunk consists of all the salmon that migrate up their home watershed from the Pacific. At each large river, big groups of

salmon branch off. Smaller and smaller groups of salmon continue on up the smaller rivers, the streams, and the headwaters. If a landslide destroys one of those uppermost branches, hundreds more remain intact. If ash from a volcano coats a dozen spawning areas, dozens more remain viable areas. In the ocean, if El Niño changes the food supply for one year, some



salmon might die, but more will be coming in the following year.

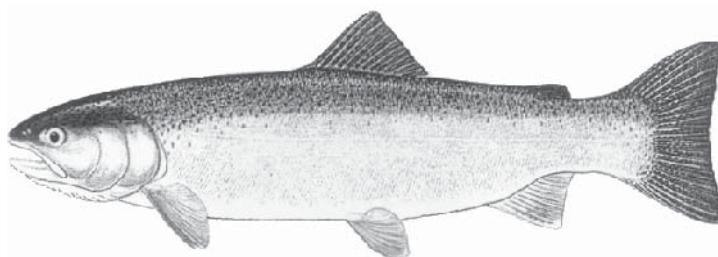
Scientists estimate that a small salmon population can recover from a natural disturbance in about ten years.

## Chinook Salmon

Records exist of Alaskan Chinook weighing 126 pounds. The record for a California River Chinook is 88 pounds. This is why people call Chinook the “king” salmon. Other nicknames include Columbia River salmon, black salmon, chub salmon, winter salmon, and blackmouth.

If you’ve ever seen spawning Chinook and noticed their dark bodies undulating with the river current, then you know why some people call them black salmon. Their mouths are also black, hence the nickname “blackmouth.” Black spots are on a Chinook’s fins and back and are most visible when they sport their mature metallic silver coloration.

Biologists recognize four types of Chinook salmon depending upon the time they enter the fresh water: spring, fall, late-fall and winter. This behavior is



genetically determined. The Sacramento River Watershed is unique among all salmon rivers because it has all four types.

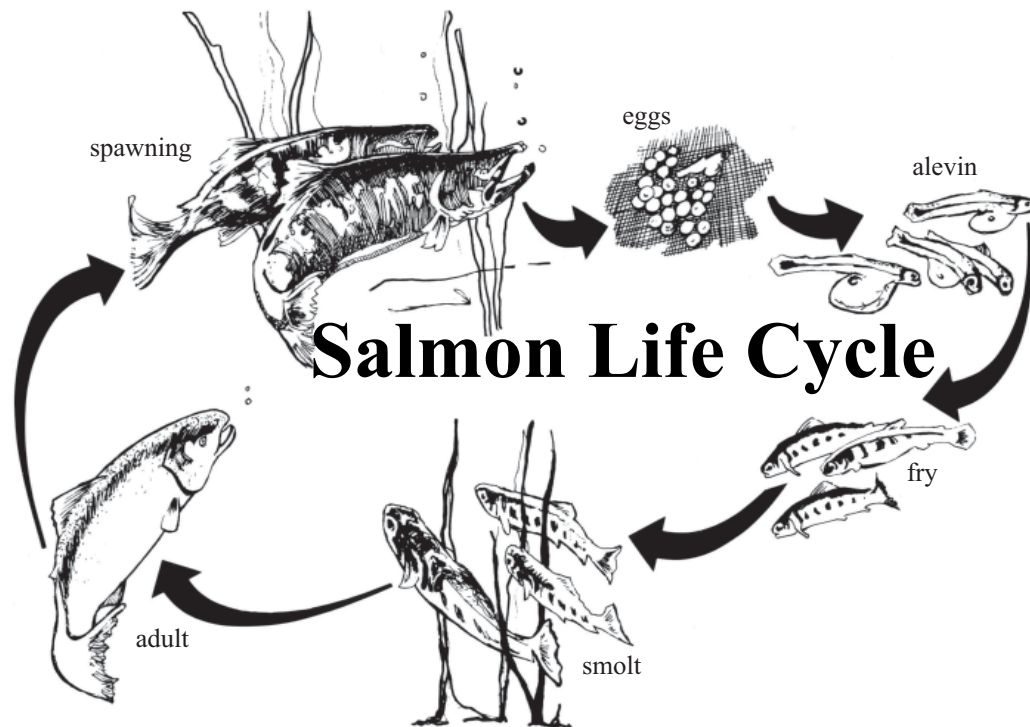
Spring Chinook migrate in the spring and summer, and spawn in the late summer and early fall. Fall Chinook migrate and spawn in—you guessed it!—the fall. In California, they usually spawn in the lowest sections of rivers.

## Steelhead Trout

When is a salmon not a salmon? When it’s a steelhead. Formerly classified as a member of a trout



Visitors to the Nimbus Hatchery learn about salmon anatomy. The Hatchery Visitor Center Interpretive Display provides information about salmon, steelhead, the American River watershed, and the role of a hatchery. For more hatchery information call (916)358-2884.



**We begin** to trace the life of Chinook salmon from its freshwater start. A bed of gravel chilled by flowing water doesn't sound appealing to us, but it's the perfect place for salmon eggs. Female salmon leave thousands of soft, pea-sized orange eggs to settle into the spaces between gravel, where they will cover the eggs with more gravel. There, they are protected from most predators. Water flows easily through the gravel, keeping the eggs cool, moist, and suffused with oxygen. The gravel nests where salmon lay their eggs are called "redds."

After a few months (depending on species and water temperature), tiny alevin (or sac-fry) hatch from the eggs. These inch-long fish still carry a yolk sac on their bellies. They remain in the gravel for several more weeks absorbing their nutritious yolk. Meanwhile, they begin to feed on bits of food that float through the gravel.

The fry swim out of the gravel and begin feeding on microscopic water animals called zooplankton. They are now considered salmon fry.

## Fry-hood

Salmon fry develop some spiffy skin marks that look like vertical black bars, called parr marks. (That's why salmon fry are also called "parr" salmon. When they grow to one and one quarter inches in length, they may also be called "fingerlings.") For tiny fish living among underwater vegetation, parr marks are

great camouflage. Like a tiger's stripes, parr marks make the fish look like lots of light and dark shapes, not one tasty fish. So they may help the tiny fish blend in with stream-bottom vegetation instead of catching the eye of bigger fish and diving ducks.

Most salmon fry stay close to home for at least several months, but some stay in their natal streams for a year or two. Some Chinook spend up to two years in their birth streams; however, they might move downstream in the fall to find better winter habitat. Other Chinook head downstream right away.

About the time that salmon fry become as long as your hand, they begin to lose their spiffy stripes and take on a sleeker appearance. They are becoming fingerling/fry, or teenagers of the salmon world.

We all know teenagers go through dramatic changes in their behavior and in their physiology. Teenage salmon have an irresistible urge to leave home and begin traveling. The signal to leave is in their genes and may be triggered by the length of day and regulated by water temperature and flow. Fingerlings/fry often begin their travels in spring or early summer when streams and rivers are running high and fast because of snow melt. The young salmon head into the current and begin their long journey to the ocean.

Some scientists think that river currents carry fingerlings/fry backwards all the way to the ocean; drifting instead of swimming would save energy.

Other scientists say they actively swim, which would use more energy but help them avoid predators. When American River salmon migrate to the Sacramento/San Joaquin Delta, they are going through some major changes. They are going through smoltification, a process by which their bodies are changing so that they can live in salt water.

Freshwater fish maintain their complex body chemistry by excreting water and taking in ions. Saltwater fish must do the opposite by taking in water and excreting ions. The changes that occur during smoltification—which involves the gills, kidneys, and other organs—allow the young salmon to begin maintaining their body chemistry in saltier water.

## Ocean Life

Salmon teenagers swim out of their smolt status and into adult life when they enter into the Pacific Ocean. If they survive their first few weeks in the coastal waters, where seals and other predators seek them, the young adult salmon will swim thousands of miles for the next one to three years. (Length of time depends on the species)

As they exit their home stream and enter into the ocean, many young salmon catch rides on the strong coastal currents that flow north and south along the Pacific coast. Chinook coming from the San Joaquin/Sacramento River Watershed of California tend to be found between Monterey and the Oregon border on the shallow Continental Shelf that extends as much as 70 miles from the coastline.

If you could follow a salmon in the ocean, you might see why these fish come all the way to salt water to feed. The ocean is like a mega-grocery store compared to the corner market of the mountain stream. The cold ocean waters are dense with food. Billions of plankton, small fish, larval crustaceans, and other forms of sea life, float and swim and migrate through these salty waters. Salmon quickly gain weight by eating a variety of foods including krill, shrimp, squid, sardines, herring, and anchovies. The salmon follow their food wherever it goes in the ocean. Suddenly, swimming thousands of miles each year makes sense.

## Coming Back Home

At some point in an adult salmon's life, it begins to swim toward home. Somehow, salmon know where they are in the ocean, when it is time to go home, and where home is. This great mystery of animal migration is known as homing, and scientists have some intriguing theories about how this migration occurs.

A salmon's ability to find a home began as soon as it hatched. At that time, the small fish was storing information about the stream's scents and geomagnetic characteristics. The fish continued storing such information about the waters as it swam downstream and out into the ocean. In this way, the young salmon created a trail to retrace in the future.

A combination of genetic impulse, day length, and level of maturity trigger the migration back home. The age at maturity is variable. Pink salmon mature at 2 years. Other species vary. Mature Chinook range in age between 2 to 7 years. The adult salmon may gather at the mouth of the home watershed, where they begin acclimating to fresh water again. And then they swim, and swim, and swim.

Consider what it must be like to have this undeniable urge to head for home. You have to walk or run hundreds of miles, and you will not eat much, if anything. Would you make it? Most humans couldn't even come close to accomplishing the journey that adult salmon must make. And salmon still have to find the energy to spawn!

Homing isn't completely accurate. Some wild salmon miss their home streams and spawn somewhere nearby. This straying of wild salmon can actually help the species by varying the genetics of the small populations in each stream. Hatchery salmon stray much more; this could pose a threat to the genetics of the wild salmon. Unlike wild salmon, the millions of hatchery salmon share only a few common parents. This limits their genetic diversity immediately, and can threaten their long-term survival and reproduction. If hatchery salmon spawn with wild salmon, they contribute their limited genetics to wild salmon, which weakens the survival of the wild species.

## Spawning Time

The sleek bodies of ocean-going salmon change as the fish migrate upstream to their spawning sites. The lower jaw of all male salmon and trout elongate and develop a hook. The genus name, *Oncorhynchus*, means “hooked nose.” Sockeye become bright red with green heads. Male sockeye also develop a hooked snout, and a humped back.

Changes in their outward appearances coincide with internal changes, like those of growing old. In salmon, these changes take place in a matter of days or weeks—not years. One scientist compares it to the aging process in humans, with salmon aging forty years in two weeks.

These well-traveled ocean veterans arrive at their spawning sites and begin one of the most spectacular displays of energy that you can see in the wild.

To spawn, all salmon must have clean and cool water with silt-free gravel. While spawning often occurs in shallow water, different species have varying needs for their spawning sites. For example, sockeye must be near a lake and Chinook can use the largest gravel up to fist-sized in diameter.

The female hovers close above a bed of gravel while facing the current. Above her, a male hovers. Downstream, another male or two might be holding position in the current. They occasionally dart in to challenge the dominant male, but he chases them away and quickly returns. The female is partner-less for only a few seconds.

She rolls onto her side so that her tail is flat against the gravel. With powerful flexes of her body, she turns her tail into a shovel and digs continually at the gravel, tossing it downstream and creating a depression in the bed. When it is deep enough, she turns rightside up and the male swims beside her. At the same time she releases her eggs into the nest, he releases his sperm. The eggs filter down into the gravel with the sperm. Almost all of the eggs will be fertilized.

The female swims upstream a few feet and begins

all over again. The gravel from this new nest will cover the previous one, protecting those eggs from predators. One female will dig a number of nests and deposit hundreds of eggs in each one. Collectively, these nests are called a redd, from the Scottish word “to make ready.”

After spawning, the male may swim off to court and mate with another female. But the spawned-out female stays by the redd to defend it from other salmon, other fish, and any other animal that might try to dig up the nest. (Other salmon pose a threat because they naturally might begin to dig where the gravel seems loose and easy to move.) Her defense lasts only a few days, though. Soon she dies, and her carcass joins those of other salmon decomposing at the bottom of the stream or caught in brush beneath the bank.

## Recycle Salmon

A salmon’s dramatic life ends with a flurry of spawning and then death. But its amazing legacy continues because dead salmon bring vast amounts of nutrients back to their home streams and habitats.

Until the 1980s, most scientists assumed that salmon carcasses were quickly washed downstream. When a salmon dies, it may be fished out of the stream by large meat-eaters such as otters, black bears, raccoons, and skunks. Scavengers fly and hop in to pick at the remains. Shrews and rodents gnaw on the bones.

Other salmon become lodged in underwater wads of roots and branches from fallen trees and shrubs. Aquatic insects take up residence in their gills and other body cavities, eating bits of flesh and scattering more of it into the water. A scientist counted more than 1,000 caddis fly larvae on one salmon head. This abundance of insects provides a feast for other fish.

Scientists have discovered these intricate connections, called nutrient webs, through ingenuity, persistence, and patience. One scientist attached radio transmitters to more than 1,000 salmon carcasses and then tracked what happened to them. Another scientist studied the

# WATERSHEDS:

## The Link to the Ocean

A watershed is a drainage area where the water that runs off the land is “shed” (runs off) into a stream, river, lake or wetland. Almost all the area of a watershed is land, not water. Almost everything that influences the stream’s ecological health occurs on that land. The amount of water carried by a stream, the shape of the channel, the chemical composition of the water, and the diverse life are all determined by the watershed and what happens within it. To fully understand a stream, one must look beyond its channels and learn about what is happening to the surrounding land.

The system of small streams which transports water, sediment and other materials from a watershed is called a *drainage network*. Watersheds and their drainage networks are interconnected land-water systems. When water falls to the earth as precipitation, the drainage network channels the water and substances it carries to a common outlet, such as the mouth of a main stream or river. From there it may flow into another large stream or river, or empty into a lake, estuary or ocean.

Like streams and rivers, watersheds vary in size. A watershed can be very small, perhaps only a few square kilometers, such as one that drains a small stream in your neighborhood. Or it can be very large, like the Sacramento River Watershed.

The highest points that surround a stream or river are called divides. If a drop of water falls on one side of a divide, it will eventually drain into that watershed’s stream or river. A drop that lands on the other side of the divide will drain into the stream or river of a different watershed.

There are four basic features of a watershed that create its unique natural characteristics: geology, climate, soils, and vegetation. Geologic processes such as glaciers, volcanoes and plate tectonics determine the underlying rock formations and their changes over geologic time. Climatic processes erode and shape these rock formations through weathering and erosional agents such as rain, snow, and wind.

Streams occur in the topography as a result of precipitation, and their movement contributes to

additional surface erosion. Streams break large rock materials down into smaller pieces; the finer materials, called sediment, are carried throughout the watersheds.

Sediment and organic matter make up the soils of a watershed and form an interface between the living and nonliving parts. Soils, in turn, have different textures, mineral content and water-holding properties. Soils therefore play a key role in watershed development because they determine which plants will grow there, how much water will run off the land, and how susceptible the land will be to erosion.

Finally, vegetation is a key feature of a watershed because plant roots slow and absorb runoff, releasing water slowly into groundwater and streams or back into the atmosphere. Vegetation also provides nutrients and habitat for fish and wildlife.

Each watershed, then, has a distinctive combination of soils and plant communities that support a diversity of habitats and a diversity of life.

The American River Watershed is a unique part of the Sacramento region. The American River is a major tributary to the Sacramento River, accounting for approximately 15% of the total Sacramento River flow. It enters the Sacramento River in the city of Sacramento. The American River drains about 1,900 square miles and ranges in elevation from 23 to over 10,000 feet. Average annual precipitation over the watershed ranges from 23 inches on the valley floor to 58 inches in the head waters. Approximately 40% of the American River flow results from snow melt. The American River has three major branches including the South Fork, Middle Fork, and North Fork. Average historical unimpaired runoff at Folsom Dam is 2.8 million acre feet (AF). (*I, DFG*) Lowest recorded runoff is 349,000 AF and the highest is 6.38 million AF.

Development of the American River began in the earliest Gold Rush days with the construction of numerous small dams and canals. Today, 13 major reservoirs exist in the drainage with total storage capacity of 1.9 million AF. Folsom Lake, the largest

reservoir in the drainage, was completed in 1956 and is now operated with a 974,000 AF capacity. Proposed additional water project developments in the basin include Auburn Dam and the 224,000 AF South Fork American River project. Folsom Dam is located approximately 30 miles upstream from the mouth. Its major purpose is flood control. It is a major element of the Central Valley Project (CVP), which is operated by the United States Bureau of Reclamation as an integrated system to meet contractual water demands, instream flow, and water quality requirements. (*I, DFG*)

The American River historically provided habitat for steelhead trout and Chinook salmon, which spawned principally in the watershed above the valley floor. Each population probably exceeded 100,000 fish. Completion of Folsom and Nimbus dams in 1955 blocked access to the historical spawning and rearing habitat for each species, and altered the flow regime in the lower American River (LAR). Salmon and steelhead runs have declined significantly in the LAR due to the combined effects of project-induced low flows, severe flow fluctuations that expose and dry out redds and strand juvenile salmonids, and high water temperatures during salmon and steelhead development. (*I, DFG*)

Historically the American River supported three runs of salmon during the Spring, Fall, and late-Fall. The larger population of spring run left the ocean in the spring to migrate to higher mountain streams where they spawned in the early fall. By the early 1900s, small dams and habitat destruction caused by mining and lumbering had greatly reduced this run. By the 1940s, when Folsom Dam was planned, this run was extinct. The fall and late-fall runs, which enter fresh water through fall and reach their spawning beds in the lower stretches of the river shortly afterwards, had most (approximately 75%) of their spawning habitat covered by the reservoirs created by Nimbus and Folsom Dams. Of the approximately 125 miles originally used, only about 8 miles of river are now left for natural spawning.

(*I Restoring Central Valley Streams: A Plan For Action, DFG Nov 93*)

## Habitat and Interdependence

Healthy habitat conditions require a highly diversified ecosystem. An ecosystem has two parts: *eco*- the

wildlife of an area (plants and animals); and *system*-their interaction with each other, and nonliving parts of the environment (air, water, and soil). Energy is the driving force that makes life possible for all the organisms in an ecosystem; the source of energy is the sun. The complex food chain ranges from microscopic diatoms and algae, to large fish, birds and mammals. The diversity of species and their numbers, particularly aquatic organisms such as fish, are important indicators of water quality, functioning foodwebs, and the health of the ecosystem.

The ideal wild salmon and trout spawning habitat is a fast-flowing stream. The water is cold, clear, and pollution-free. It meanders at varying depths over gravel and rocks, churns around boulders and fallen trees, and now and then swirls into quiet backwater pools.

The streamside, or riparian zone, is usually shaded by trees. The tree roots make the stream banks stable and provide hiding places for fish. Leaves from the trees fall into the stream and become food for insects, which are in turn eaten by salmon and trout.

As young salmon and trout grow larger, they move from shallow areas into deep pools. [Pools are scoured when water plunges, or around boulders and logs.] The “bubble curtain” is a favorite place for salmon and trout. They can’t be seen by predators above and there is plenty of oxygen. The current brings insects and other small food items. At the end of pools, where the stream narrows, the current picks up and washes the gravels clean, making them ideal for nests.

Anadromous salmonids spend part of their lives in salt water. These fish leave their streams and migrate out to the ocean. At the river’s mouth, fresh water flows into the sea. The seas also surge into the river, and salt water mixes with fresh water. This area of brackish water is the estuary. Migrating fish stay in the estuary for awhile before entering the ocean. They find new types of food to eat and grow larger, which helps them survive in the ocean. Their bodies also adjust to the salt water. In the ocean they find rich sources of food and grow rapidly, eating smaller fish and krill. They may swim many miles up and down the coastline between Monterey and Point

# Cultural Perspectives and Human Impact

Salmon swim into the rivers around the northern rim of the Pacific—and everywhere that salmon swim, they have become a part of the local culture. The Ainu, who live on the island of Hokkaido in Japan, make ceremonial robes of salmon skins. On the Kamchatka Peninsula of Russia, salmon bones have been found mixed with the remains of a human community that is eleven thousand years old. And from Alaska to California, salmon have formed the base of tribal cultures.

## California's First Settlers

California's first settlers probably arrived from the north 10,000 to 12,000 years ago and they settled near natural waterways.

California's first people found the land of the Great Valley to be a rich habitat with rivers, vast areas of grassland, fair quantities of variable woodland, and chaparral. The woodland provided deer, vegetables and the staple acorns; the grasslands provided antelope; the rivers provided salmon and other fish, and the large gallery forests along the riparian corridors provided more acorns. Fishing was important. Salmon, sturgeon and lampreys were taken primarily by net, and often in conjunction with reed rafts or boats made of tules. The fish were usually roasted and eaten. However, much of the salmon was dried and stored to use throughout the year. Their material economy was based on the plants and animals in the valley, which they utilized for food and fiber as well as for medicine, utensils, dress and decoration. Tribes built villages with dome-shaped houses from a pole frame covered with tules, brush and earth. They built ceremonial structures and sweatshouses partly dug into the ground. The residents of each village cared for the land around them and maintained a spiritual connection with the river habitat.

For northwestern tribes like those of the Klamath and Trinity rivers, salmon was a large portion of their diet. Consequently, ceremonies thought to ensure the bounty of the salmon were of great importance. These tribes' life cycles, religions and wars focused on the rivers, particularly the salmon of those rivers.

Tribes of the central valley included the Valley Maidu, called the Nisenan, the Patwin to the west

and the Interior Miwok to the south. These people were provided with an abundance of game, fish and plants due to seasonal variations. Salmon was a very important food; however, there is no documentation of salmon ceremonies. An interesting note is that the Interior Miwok people named the river that flows through their land the Cosumnes which means "returning salmon."

## European-Americans

Captain Meriwether Lewis, of the Lewis and Clark expedition, encountered salmon immediately after crossing the Continental Divide into the watershed of the Lemhi River. Lewis and his companions were out of food. The Shoshone offered the men salmon, along with other food. In *Lewis and Clark: Pioneering Naturalists*, Paul Cutright quotes Lewis: "This was the first salmon I had seen, and perfectly convinced me that we were on the waters of the Pacific Ocean."

Adventurers soon followed Lewis and Clark using routes over the mountains and inland from the ocean. In the Sacramento Valley, miners stirred up streams in their search for gold and other precious minerals. Settlers cut down old-growth forests adjacent to the river. Farmers and ranchers devised irrigation methods that used rivers to water the semi-arid but fertile lands. And fishermen caught, trapped, netted and took every salmon as if the resource was limitless.

Since 1839 the Sacramento region has been populated by people of diverse racial, ethnic and national origins, including fur trappers, gold-seekers, farmers, miners and merchants.

## In the Twenty-First Century

Today, salmon remain important for their cultural, aesthetic, recreational and economic value. The National Research Council stated in its 1996 report, *Upstream: Salmon and Society in the Pacific Northwest*, that

*"Salmon have provided social continuity and heritage for many Americans—the American Indian tribes and non-Indian fishing communities that depend on salmon fishing, the generations of sport*

*anglers proud of their pursuits of steelhead and other salmon, the general public of the Northwest who have adopted salmon as a regional symbol."*

## Impacts

Today, we are aware that salmon are in trouble. Commercial fisheries, biologist, and engineers have tried many methods for helping salmon. To boost population, hatcheries were built beginning in the 1870s; but, their success has been mixed. For any salmon recovery effort to succeed, we must look honestly and completely at the obstacles and make some difficult decisions.

Few of the naturally spawned salmon return to renew the population. Predation, disease, competition, and natural disasters take their toll as they have always done. The salmon population were adapted to these hazards and thrived, but during the past 150 years, human-created perils have greatly reduced the number of salmon. By the turn of the century, the American River spring run was nearly extinct due to habitat destruction and blockage of spawning beds; by the 1940s it was extinct. Nearly 125 miles of the American River and its forks provided spawning sites for salmon and steelhead; now, only eight miles remain between Ancil Hoffman Park and Nimbus Dam.

The completion of Sacramento's Folsom and Nimbus Dams in 1956 blocked 75% of the remaining beds on the American River. The U.S. Bureau of Reclamation, which owns the dams, built and funds the Nimbus Fish Hatchery to mitigate this loss of habitat. The hatchery is operated by the California Department of Fish and Game. In 1993, the hatchery was modernized and a visitor center was added. The visitor center and hatchery are open year round from 8 a.m. to 3 p.m. Visitors may watch artificial spawning of salmon and steelhead from inside the visitor center. Fish can be seen in the raceways outside and at the American River Fish Hatchery immediately downstream from the Nimbus Hatchery. (The American River Fish Hatchery raises mainly rainbow trout for release in freshwater streams and lakes in the surrounding 17 county areas.)

The salmon are drawn into the hatchery by their instinct to keep swimming upstream until they find their spawning beds. A fish ladder—a series of small

pools connected by small waterfalls—allows them to move up to the holding pool of the hatchery. The fish ladder is not operated until the water is cool enough for successful spawning. A recorded message on the hatchery information phone attempts to keep the public aware of times when egg taking may occur. The number is (916) 358-2884.

Good sites to view spawning in Sacramento County include: the upper end of the riffles at Effie Yeaw Nature Area of Ancil Hoffman Park; in a side channel of the river about a quarter mile upstream from the Sunrise Bridge on the south side; and, for an overview, from the bluffs at the east end of the upper Sunrise area (enter from the road to Fish and Game Region II offices off Gold Country Boulevard). Another good place to watch fish is from the bicycle bridge between William Pond Park and Goethe Park. During the day the river between the Hazel Avenue Bridge and Nimbus Dam is always open. The spawning areas are seasonally closed to fishing (see Fish and Game regulations for exact dates and areas).

## Obstacles

Dams present the most obvious and serious obstacles to salmon. The Nimbus Hatchery provides mitigation for the Folsom Dam, which prevents salmon from completing their migration upstream. Fish hatcheries seem to be a great way to protect salmon species from extinction. In protected and controlled environments, millions of salmon eggs hatch and millions of salmon fry grow to smolt without risk of predation. And all these millions of protected smolts can then be released into the rivers and the ocean to grow into adult salmon that will find their way home. That's the theory. However, hatchery management and release of billions of hatchery-raised salmon has not stopped the decline of "wild salmon." Hatchery salmon face the same problems as wild fish, such as having to dodge predators, navigate past dams, and find their way back home again to spawn.

Hatcheries can play an important role in providing recreational and commercial fish and are used as a tool of fisheries management. Hatcheries are continually changing as more information is learned about the lives and needs of wild fish. The future of wild fish and hatchery management are partners in fish resource management.

**Sedimentation** is caused by excess amounts of silt and other particles entering streams and rivers. Surface erosion sends small amounts of particles into the water. Mass erosion (i.e. landslides) dumps huge amounts of dirt into water. Causes of surface erosion vary. Regardless of the source, sedimentation affects salmon by smothering eggs, reducing nutrients, and altering stream energy and velocity. Landslides and earth slumps can trap young salmon in their natal streams and block adult salmon from returning to spawn. Several things can be done to protect salmon from sedimentation: improved logging and road construction practices can reduce sedimentation by half, cattle can be kept out of streamside areas, recreationists can be educated to avoid trails that increase erosion, and everyone can decrease erosion by planting native plant species in streamside areas.

**Loss of cover** affects salmon in several ways. Tree trunks and root balls provide shelter for young salmon and help capture nutrients brought in by the water flow. Vegetation on stream banks also provide shade for salmon and keeps the water cool. Streamside vegetation can be protected by keeping cattle away and rerouting trails. New construction of roads, houses, and other development can be restricted from streamside areas.

**Altered stream flow** includes increasing or decreasing the amount and velocity of water in rivers and streams. Such alterations can throw off the timing of incubation, hatching, development, migration, and spawning.

**Pollution** of streams and rivers comes from point (traceable) sources, like factory discharge, and non-point sources, such as storm runoff and fertilizers. Until recently, people have often been careless about disposing of household wastes, such as used motor oil and cleaning supplies.

**Alteration of wetlands** through diking, draining, or filling, affects salmon directly and indirectly. Young salmon sometimes find shelter and abundant food in wetlands adjacent to streams and lakes. As such areas are drained or filled, salmon lose food and

shelter.

## What About Fishing?

Commercial salmon fishing has supported hundreds of thousands of people in the Pacific Northwest, and salmon provides much excitement and pleasure for sports anglers. Commercial and sport license fees fund many stream restoration and hatchery programs. Many people have blamed some of the salmon decline on commercial fishing. But, even when this industry has been restricted, salmon numbers have continued to decline.

## Stewardship: Restoration Can Happen

No matter how hopeless the plight of salmon might seem, scientists remain confident that salmon can be restored:

- Maintain genetic diversity; make this the primary goal of all salmon management.
- Consider the variability of ocean conditions when making fishery management decisions.
- Increase protection of river habitats.
- Improve smolt survival.
- Change hatchery focus from production to research, and become part of a coordinated regional plan for salmon restoration.
- Develop cooperative management that uses local knowledge, provides long term incentives for the future, and balances local interests.

## How you can help

The story told in the book *Come Back, Salmon* by Molly Cone, is about one elementary school that adopts a stream, cleans it, tests the water for pollution, and raises salmon in their classroom to release into the stream. Two and 1/2 years later, salmon returned to a stream that had not had any salmon for over twenty years! Salmon need clean water to live and humans can help. No matter what your age or where you live, there is something you can do to help salmon.

- Conserve water; less wasted water can mean more water for salmon and other fish living in streams,



# Salmonids at the Hatchery

*(Above)* Mature, adult spawning salmon are brought into the hatchery. Hatchery personnel select females that are ripe, or ready to release eggs.

*(Top right corner)* Eggs are removed from the female. Milt for the male is mixed with the eggs.

*(Middle)* The fertilized eggs are prepared for incubation. Egg development depends on carefully monitored water temperature.

Once the eggs hatch, the alevin or sac fry have a large yolk sac attached to their belly. This sac is the main source of their nourishment. Once the yolk sac is used up, the developing salmon are called fry.

*(Bottom)* The fry are placed in ponds, or raceways, and fed a starter diet. As they grow, the amount of food is steadily increased. Releasing hatchery

